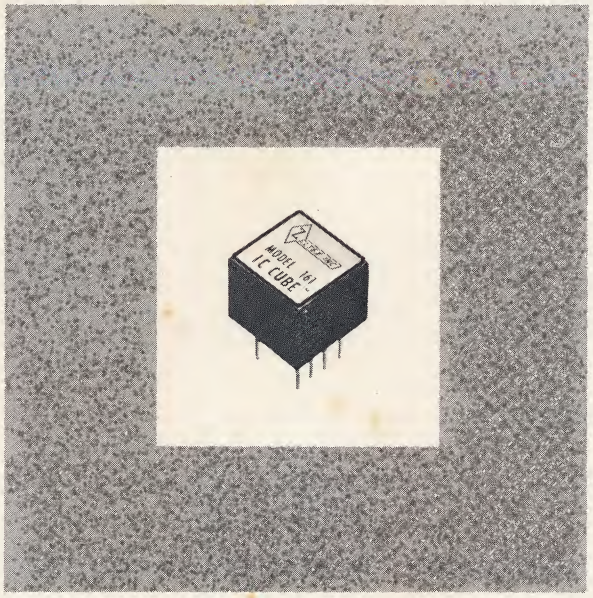
ZELTEX, INC.
1000 CHALOMAR ROAD
CONCORD, CALIFORNIA 94520
PHONE (415) 686-6660

DIFFERENTIAL OPERATIONAL AMPLIFIER

IC CUBE * MODEL 161



- 0.1 CUBIC INCH PACKAGE (0.5 x 0.5 x 0.4 in.)
- FULLY STABILIZED (6 dB Roll-off)
- SHORT-CIRCUIT PROOF
- 10V COMMON MODE
- HIGH DC GAIN (100,000 Typical)
- FAST SLEW RATE (10 V/us)

DESCRIPTION

The Zeltex Model 161 "IC Operational Cube" is a sub-miniature differential operational amplifier of hybrid integrated circuit construction. In contrast to monolithic chip amplifiers, it is a fully-compensated, general-purpose op amp, requiring only the addition of input and feedback components to become operational.

FEATURES

The 161 is designed with a constant 6 dB per octave roll-off characteristic, which means excellent frequency stability without the need for external stabilizing networks. For this reason, the IC CUBE is generally easier to install and requires less space than monolithic type amplifiers. In spite of its small size (0.1 cubic in.), it features premium performance to match or exceed that of present generation op amps of one cubic inch or larger: DC open loop gain is 100,000 typical; voltage drift, 25 uV/°C max; current drift, 1.5 nA/°C max; common mode rejection, 80 dB (10,000:1) typical. Output capability is ±10V at 4mA with full short-circuit protection. The amplifier also has a wide safety margin with respect to power supply levels.

PACKAGE

The 161 case size is 0.5 x 0.5 x 0.4 in. Its lead spacing on a 0.1 in. grid permits flush mounting of the amplifier to the circuit board, thus eliminating the need for troublesome lead splaying.

Litho in U.S.A.

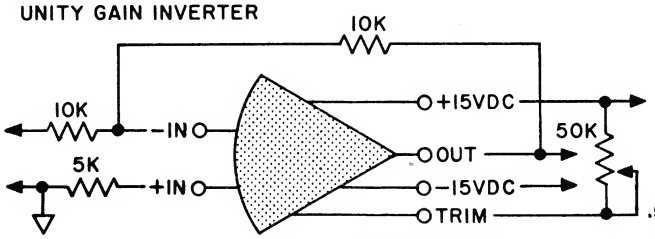
PERFORMANCE SPECIFICATIONS

OUTPUT RANGE	±10V @ 4mA min
COMMON MODE VOLTAGE	±10V min
DC OPEN LOOP GAIN	80,000 min
GAIN-BANDWIDTH PRODUCT	1.5 MHz min
FREQUENCY FOR FULL OUTPUT	100 kHz min
Equivalent Slew Rate	6V/us min
VOLTAGE OFFSET	Externally adjustable to zero
Drift vs. Temp.	25 uV/°C max
Drift vs. Power Supply	100 uV/V max
Drift vs. Time	25 uV/day max
INPUT CURRENT OFFSET	150 nA max
Drift vs. Temp.	1.5 nA/°C max
Drift vs. Power Supply	1 nA/V
Drift vs. Time	5 nA/day
INPUT IMPEDANCE	
Differential	200K min
Common Mode	20 Meg min
NOISE	
Wideband (20 kHz BW)	30 uV p-p
COMMON MODE REJECTION RATIO	70 dB from DC to 60 Hz min
TEMPERATURE RANGE (OPERATING)	-25° to +85°C
POWER SUPPLY REQUIREMENT	±15V @ 4mA quiescent
PHYSICAL CHARACTERISTICS	Case 0.50 x 0.50 x 0.40
PRICE (1-9)	$65

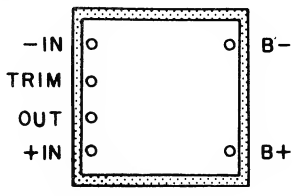
MECHANICAL SPECIFICATIONS

CIRCUIT DIAGRAM (TYPICAL)

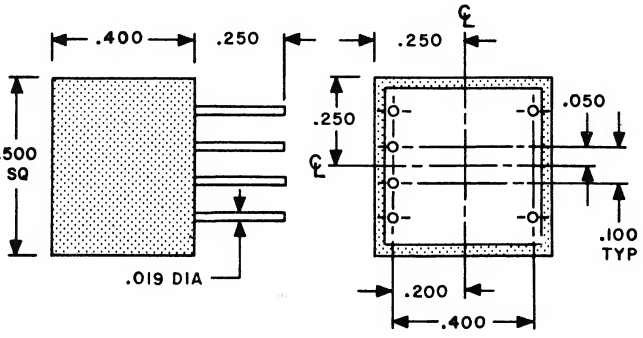
UNITY GAIN INVERTER



PIN FUNCTIONS



CASE DIMENSIONS



OPERATIONAL AMPLIFIER

MODEL 145

ZELTEX, INC.
Concord, California
1000 Chalomar Road
Phone (415) 686-6660

FEATURES

- **LOW DRIFT—0.5μV/°C and 2 pa/°C**
- **HIGH SLEWING RATE—100 V/μsecond**
- **WIDE BANDWIDTH—100 MHz**
- **HIGH OUTPUT—±10 V @ 25 ma**
- **WIDE OPERATING RANGE—**
  —55°C to +85°C

DESCRIPTION

The Model 145 Amplifier uses a solid state (FET) chopper to reduce voltage and current drift to a maximum of 0.5μV/°C and 2 pa/°C. Typical performance is 0.2 μV/°C and 1 pa/°C. Long term drift is typically 1 μV/day. The small size and weight of the 145 allows mounting directly on an etched circuit card along with associated networks to minimize stray capacity and noise pickup and to eliminate cabling. Chopper drive is internal, and the only supply levels required are a nominal ±15 VDC. The amplifier is very insensitive to the supply levels and can be powered with voltages in the range from ±12 to ±18 VDC without modification. A 1% shift in either supply level causes an input voltage drift of only 0.1 μV.

FAST RESPONSE

The 145 is also a very fast amplifier. Full output voltage is available to above 1.5 MHz and the slewing rate exceeds 100 V/μsecond. The gain bandwidth product is normally 3 MHz. For applications requiring higher gain bandwidth, connection of a resistor to a bandwidth trim terminal can yield gain bandwidths between 3 MHz and 100 MHz (see reverse side for details).

The high speed path of the 145 is an integrator at high frequency with an input resistance of 10 Kohm. Connection of a BW trim resistor between terminals 8 and 9 effectively shunts the input resistance to a lower value which lowers the high frequency input impedance and increases the gain bandwidth of the amplifier.

PACKAGE

The 145 is housed within a diecast aluminum case which offers excellent shielding and maintains the low noise level of 4 μV, p-p, even in noisy environments. The case can be inserted into a mating connector or bolted to an etched circuit card. It is normally supplied unencapsulated, and is factory repairable.

For MIL requirements, the amplifier can be supplied encapsulated within the case for rugged environmental applications. Operation over the temperature range from —55°C to +115°C is also available on special order with relaxed output power specifications.

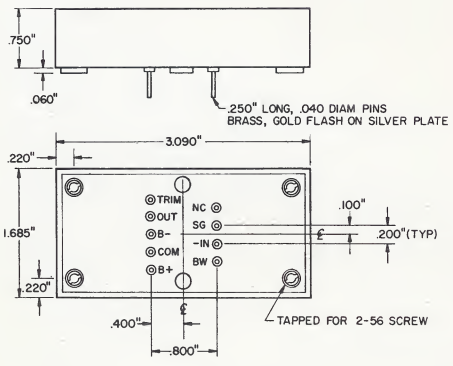
LITHO IN U.S.A.

BULLETIN NO. 1009A

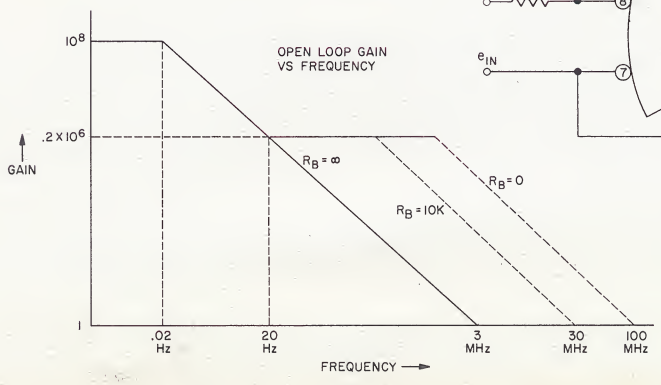
SPECIFICATIONS *(Typical @ 25°C unless otherwise noted)*

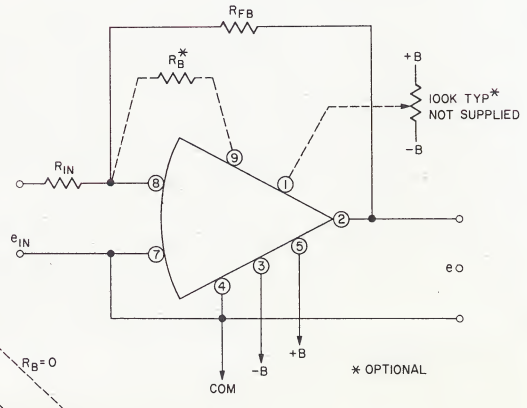
RATED OUTPUT	
Voltage, p to p, min.	±10 V
Current, min.	25 ma
OPEN LOOP GAIN	
@ DC, min.	10^8
Rate of roll off	—6 db/octave
INPUT OFFSET VOLTAGE	
@ 25°C, max. (adjustable to zero)	25 μV
Average vs temp. (—25°C to +85°C), max.	0.5μV/°C
(—55°C to +85°C), max.	1 μV/°C
vs time	1 μV/day
vs supply voltage	0.1 μV/%
INPUT OFFSET CURRENT	
@ 25°C, max. (adjustable to zero)	100 pa
Average vs temp. (—55°C to +85°C), max.	2 pa/°C
vs supply voltage	0.1 pa/%
FREQUENCY RESPONSE	
Gain bandwidth product (adjustable)	3 MHz—100 MHz
Full output voltage, min.	1.5 MHz
Slew rate, min.	100 V/μsec
INPUT CHARACTERISTICS	
(single ended, inverting)	
Input impedance, DC, open loop	300 K
Voltage noise, DC to 2 Hz, p to p	4 μV
2 Hz to 10 KHz, rms	10 μV
POWER SUPPLY	
Voltage (±15 V is design center)	±12 to ±18 VDC
Current, quiescent	12 ma (@ 15 VDC)
TEMPERATURE RANGE	
Operating	—55°C to +85°C
Storage	—55°C to +100°C

TERMINAL		FUNCTION
1	TRIM	OFFSET ADJUST*
2	OUT	OUTPUT
3	B—	—15 VDC
4	COM	SUPPLY COMMON
5	B+	+15 VDC
6	NC	NO CONNECTION
7	SG	SIG GND
8	—IN	INVERTING INPUT
9	BW	BANDWIDTH SELECTION*



Zeltex Case Style K





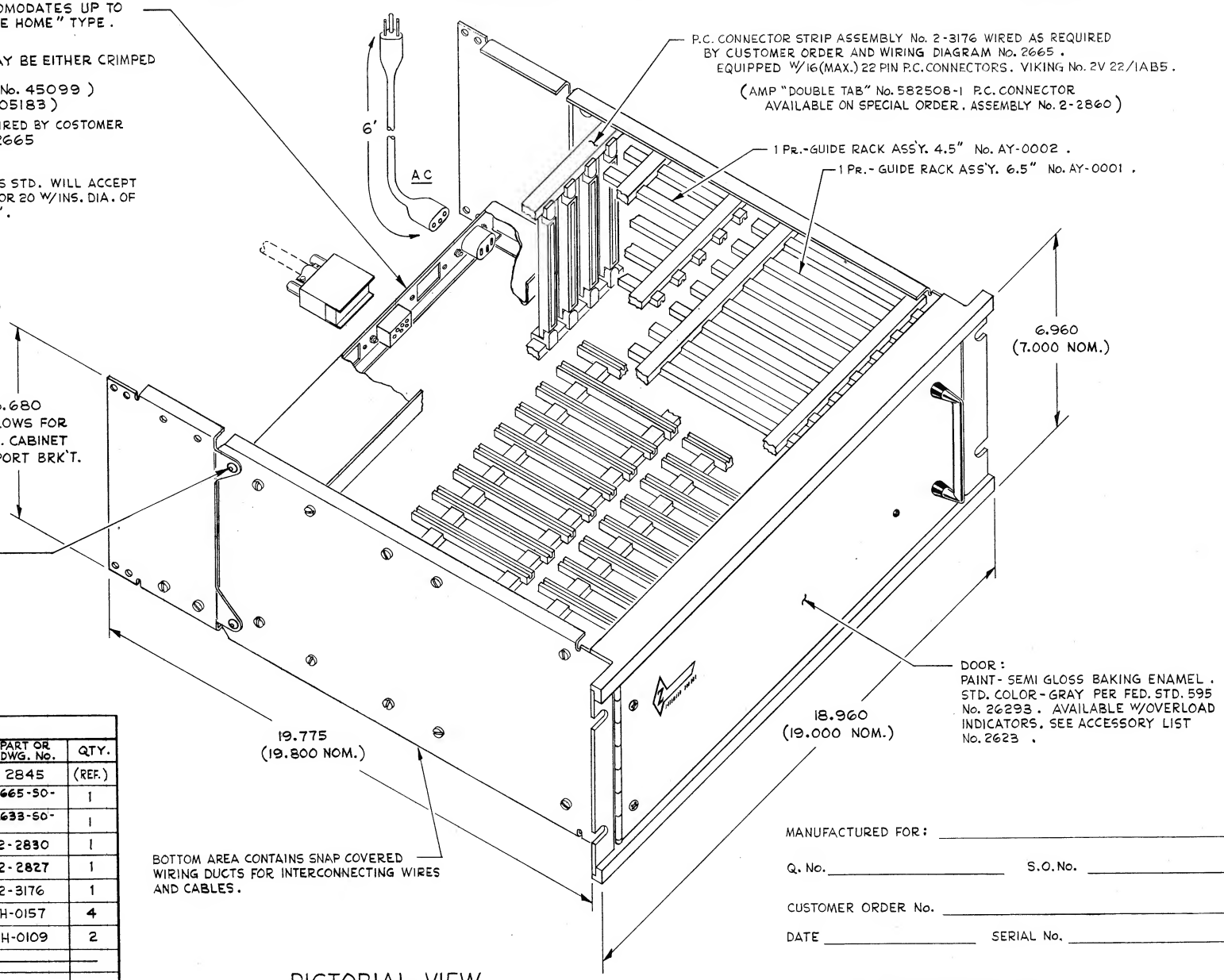
1.) EXTERNAL CONNECTOR STRIP ACCOMODATES UP TO 8, 26 PIN CONNECTORS OF THE "POKE HOME" TYPE. (AMP SERIES "M")

** MATING CONNECTOR * PINS MAY BE EITHER CRIMPED OR SOLDERED.
(CRIMP TOOL - AMP HAND TOOL No. 45099)
(EXTRACTION TOOL - AMP No. 305183)

2.) CONNECTORS TO BE WIRED AS REQUIRED BY COSTOMER ORDER AND WIRING DIAGRAM No. 2665

* PINS AND SOCKETS FURNISHED AS STD. WILL ACCEPT AWG STRANDED WIRE SIZE 24, 22 OR 20 W/INS. DIA. OF .075 MAX. STRIP LENGTH = 13/64".

** CONSISTS OF:
1 - PIN BLOCK No. 200513-3
1 - 2 PIECE SHIELD No. 201576-1
1 - JACK SCREW, MALE No. 200871-1
1 - JACK SCREW, FEMALE No. 200867-1
26 - CONTACT PINS No. 201330-1



PICTORIAL VIEW

PARTS LIST			
No.	TITLE	PART OR DWG. No.	QTY.
1	FINAL ASSEMBLY DWG.	2845	(REF.)
2	WIRING DIAGRAM	2665-50-	1
3	WIRE LIST	2633-50-	1
4	BASIC ASS'Y. - COMMON PARTS & HDW.	2-2830	1
5	AUX EXTENSION ASS'Y. STYLE 2	2-2827	1
6	P.C. CONNECTOR STRIP ASS'Y.	2-3176	1
7	SCREW, 6-32 X 5/16 BHMS, CAD. PL. STL.	H-0157	4
8	WASHER, No. 6 FLAT " " "	H-0109	2
9	(USE ITEMS 7 & 8 TO MOUNT ITEM 6)	———	———
10			
11			
12	ACCESSORY LIST	2623-50-	1
13	SHIPPING KIT	2625-50-	1
14			
15			
16			

MANUFACTURED FOR: _____

Q. No. _____ S.O. No. _____

CUSTOMER ORDER No. _____

DATE _____ SERIAL No. _____

SHT. ____ OF ____

FORM REV. 7-12-66

TOLERANCES (EXCEPT AS NOTED)	MATERIAL - TREATMENT - FINISH				
HOLE DIA. ±					
DECIMAL ±					
FRACTIONAL ±	NEXT ASS'Y				
ANGULAR ±	DRAWN LT	CHECKED	APPR'D		
DATE 7-12-66	SCALE NONE	MODEL 560	STYLE -2		
TITLE MODEL CONTROL & OUTLINE DRAWING		CODE IDENT. NO. 17850	DWG. NO. 2634-50-	ISSUE SP	

ISSUE	E.C.D.	DATE	PR. ENG.
SP	652	8/9/66	

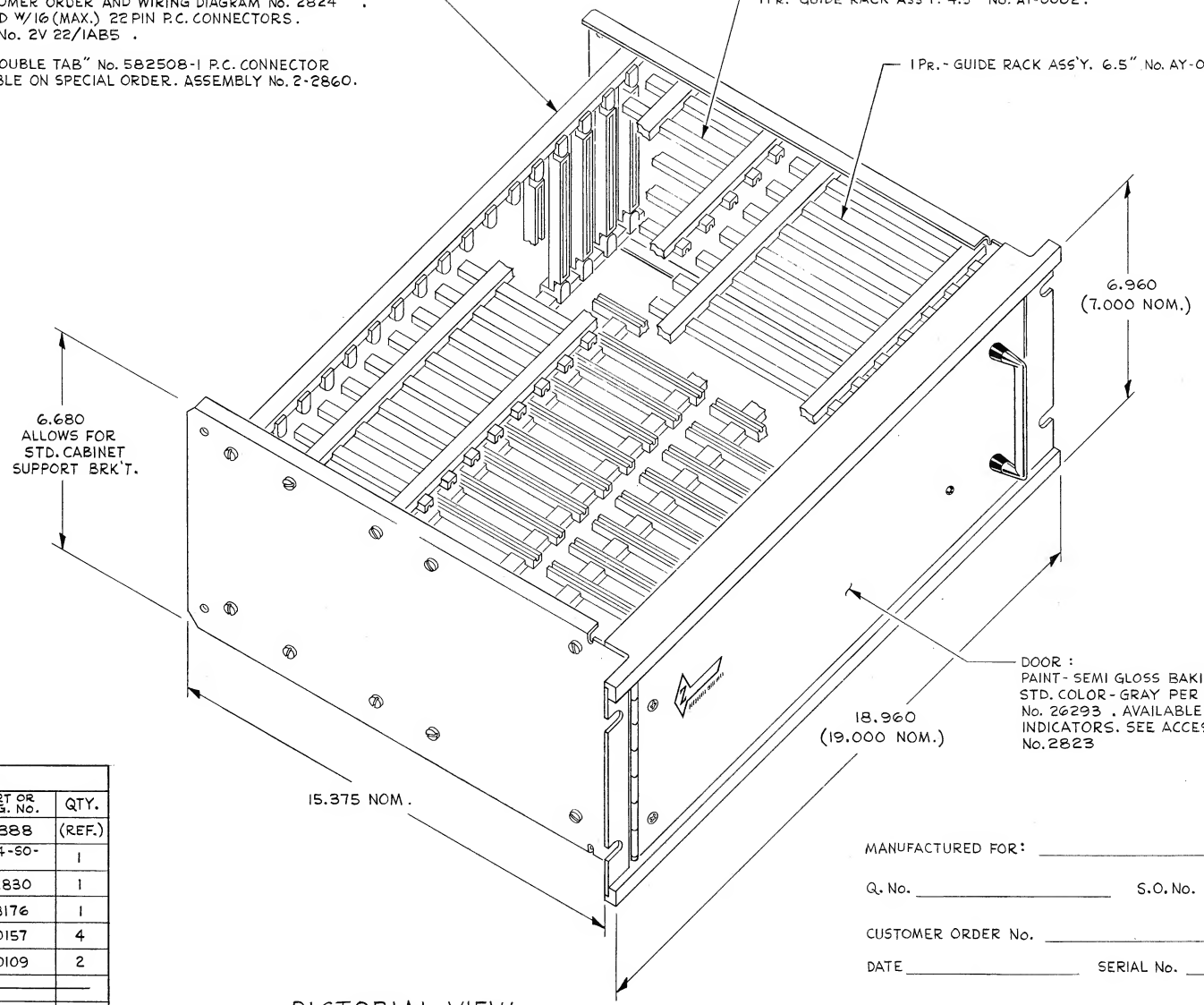
ZELTEX INC.
CONCORD, CALIFORNIA

P.C. CONNECTOR STRIP ASSEMBLY No. 2-3176 WIRED AS REQUIRED BY COSTOMER ORDER AND WIRING DIAGRAM No. 2824 . EQUIPPED W/16 (MAX.) 22 PIN P.C. CONNECTORS. VIKING No. 2V 22/1AB5 .

(AMP "DOUBLE TAB" No. 582508-1 P.C. CONNECTOR AVAILABLE ON SPECIAL ORDER. ASSEMBLY No. 2-2860.

1 PR.-GUIDE RACK ASS'Y. 4.5" No. AY-0002.

1 PR.-GUIDE RACK ASS'Y. 6.5" No. AY-0001 .



DOOR :
PAINT - SEMI GLOSS BAKING ENAMEL
STD. COLOR - GRAY PER FED. STD. 595
No. 26293 . AVAILABLE W/OVERLOAD
INDICATORS. SEE ACCESSORY LIST
No. 2823

PICTORIAL VIEW

PARTS LIST			
No.	TITLE	PART OR DWG. No.	QTY.
1	FINAL ASSEMBLY DWG.	3388	(REF.)
2	WIRING DIAGRAM	2824-50-	1
3	BASIC ASS'Y. - COMMON PARTS & HDW.	2-2830	1
4	P.C. CONNECTOR STRIP ASS'Y.	2-3176	1
5	SCREW, 6-32 X 5/16 BHMS, CAD. PL. STL.	H-0157	4
6	WASHER, No. 6 FLAT " " "	H-0109	2
7	(USE ITEMS 5 & 6 TO MOUNT ITEM 4)	———	———
8			
9			
10			
11			
12	SHIPPING KIT	2625-50-	1
13	ACCESSORY LIST	2823-50-	1
14			

MANUFACTURED FOR: _____

Q. No. _____ S.O. No. _____

CUSTOMER ORDER No. _____

DATE _____ SERIAL No. _____

SHT. _____ OF _____

FORM REV. 7-21-66

TOLERANCES (EXCEPT AS NOTED)	MATERIAL - TREATMENT - FINISH			SP 652 8/9/66
HOLE DIA. ±				ISSUE E.I.D. DATE PR. ENG.
DECIMAL ±				
FRACTIONAL ±	NEXT ASS'Y			ZELTEX INC. CONCORD, CALIFORNIA
ANGULAR ±	DRAWN LT	CHECKED	APPR'D	
DATE 7-21-66	SCALE NONE	MODEL 560	STYLE -1	
TITLE	MODEL CONTROL & OUTLINE DRAWING		CODE IDENT. NO. 17850	DWG. NO. 2650-50- ISSUE SP

ZELTEX, INC. 1000 CHALOMAR ROAD • CONCORD, CALIFORNIA 94520 • PHONE (415) 686-6660
SPECIALISTS IN AMPLIFIERS AND COMPUTER ELEMENTS

DETAIL SPECIFICATIONS, ZELTEX 1045 MULTIPLIER SUBSYSTEM

I. GENERAL

1. Designed for ready integration with virtually any installed large analog computer, e.g., EASE, PACE consoles.
2. Prewired, powered and cabled for 30 SCI-Class 2 128-section quarter-square solid-state multipliers.
3. All-silicon solid-state plug-in components.
4. 60 assigned, patchable wideband inverters.
5. 4-quadrant multiply, 2-quadrant divide (positive denominator).
6. Square-root on alternate multipliers.
7. Cabtron FS-1970-22LPB cabinet, 77 x 22 x 21" (HWD).
8. Weight, with full complement, cables and packing, 750#.
9. Less than 10 amperes, 115 $\pm$ 10v., 60 hz.
10. Less than 90 ma. load on $\pm$ 100v. computer reference, full complement.
11. Cabling to console furnished according to layout and console type.
12. Overlays for 12 patchboards supplied as specified by client.
13. Polarity can be changed by jumper connection.
14. Downtime required for integration ranges from a few hours (e.g., EASE 2100 series) to one week (PACE 231-R series).

II. INPUT CHARACTERISTICS

1. Multiplier input resistance: greater than 30 Kilohms.

2. Multiplier input shunt capacity: 60 pf. plus that of cabling specified.

3. Inverter input resistance: 200 Kilohms.

4. Inverter input shunt capacity: 50 pf. plus that of cabling specified.

5. Inverter ejection current: less than 10 picoamperes $\pm$ 1 picoampere/^{o}C.

6. Inverter voltage offset: less than 2 microvolts $\pm$ 2 microvolt/^{o}C.

7. Multiply input range: $\pm$ 150 volts, either X or Y.

8. Divide input range: $\pm$ 100 volts or X, 0 to +150 volts on Y.

9. Square-root input range: $\pm$ 100 volts.

10. Multiplier reference input: less than 3 ma. from reference $\pm$ 100 v.

11. Audio and visual alarms:

    (a) Lights on each amplifier (inverters and output driver).

    (b) Amplifier lights duplicated on subsystem frame.

    (c) Amplifier lights trip on less than 1 mv. junction error, detecting overvoltage and/or overcurrent.

    (d) Additional multiplier light detects (X) + (Y) $\geq$ 200 v.

    (e) Any alarm in subsystem produces tone/volume-variable audio signal.

III. OUTPUT STATIC CHARACTERISTICS

1. Multiplier/Inverter current capability:

   (a) Internally limited to withstand short-circuits to ± 170 v. sources.

   (b) Short-to-ground current: less than 20 ma.

   (c) Resistive load, full drive, -100 through 0 to +100 v.: 2.5 Kilohms.

   (d) + or - 150v. current: more than 5 ma.

   (e) + or - 125v. current: more than 25 ma.

   (f) + or - 100v. current: more than 40 ma.

2. Multiplier static error:

   (a) X=0, Y=0 : less than ± 2 mv. (± 0.002% FS)*

   (b) $-100 \leq X \leq +100$, Y=0: less than ± 10 mv. (± 0.01% FS)

   (c) X=0, $-100 \leq Y \leq +100$: less than ± 10 mv. (± 0.01% FS)

   (d) X=100 v., Y=100 v.: 100.000 volts ± less than 25 mv. (± 0.025% FS)

   (e) Any point in the X, Y plane bounded by X, Y = ± 100v.: less than ± 25 mv. error (± 0.025% FS)

   (f) Additional error between ± 100v. square and ± 150 v. circle on the X, Y plane: less than ± 5 mv. (± 0.005% FS)

3. Multiplier noise, 10 hz.-80 Khz.: less than 10 mv. peak-to-peak (± 0.005% FS)

4. Inverter noise, 10 hz.-80 Khz.: less than 5 mv. peak-to-peak (± 0.0025% FS)

5. Multiplier tempco, ± 10°C: less than 1 mv. /°C (0.001% FS/°C)

6. Multiplier regulation, 0 to ± 40 ma.: less than ± 1 mv. (± 0.001% FS)

7. Multiplier drift, 10 hours, constant temperature and load: less than ± 1 mv. (± 0.001% FS)

8. Inverter drift, 10 hours, constant temperature and load: less than ± 0.5 mv (± 0.0005% FS)

9. Multiplier/Inverter capacitive loading, stable region: more than 0.1 microfarad (higher values with series resistance).

* Note: Full Scale is defined as 100 volts, <u>not</u> 200 volts (± 100 volts).

IV. OUTPUT DYNAMIC CHARACTERISTICS

1. All measurements taken AT PATCHBOARD with 13-foot input shielded cable and 13-foot output shielded cable (Jefflex #24 AWG, 0.080" O.D., common drainwired to PB ground).

2. Multiplier/Inverter slewing limit: greater than $30 \cdot 10^6$ volts/second.

3. Divide slewing limit: greater than $15 \cdot 10^6$ volts/second.

4. Inverter frequency response:

   (a) 3-db. down from 20 v. peak-to-peak sinewave: more than 500 Khz.

   (b) 3-db. down from 200 v. peak-to-peak sinewave: more than 70 Khz.

   (c) Peaking: less than 0.1 db. (above 100 Khz.)

5. Multiplier frequency response:

   (a) 3-db. down from 200 v. peak-to-peak sinewave: more than 60 Khz.

   (b) Peaking: less than 1 db. (above 10 Khz.)

6. Divide frequency response:

   (a) 3 db. down from Y=100 v., X=100 sin wt. : more than 20 Khz.

   (b) Peaking: 0 db.

7. Multiplier phase shift (axis crossing of fundamental component):

   (a) 100 hz. : less than 0.02°

   (b) 400 hz. : less than 0.10°

   (c) 1 Khz. : less than 0.40°

   (d) 10 Khz. : less than ~~8.0°~~ 10°

8. Inverter phase shift:

   (a) 100 hz. : less than 0.01°

   (b) 1 Khz. : less than 0.10°

   (c) 10 Khz. : less than 1.0°

   (d) 100 Khz. : less than 10°

IV. OUTPUT DYNAMIC CHARACTERISTICS (continued)

9. Multiplier total maximum dynamic error (input plus output), X = 100 v., Y = 100 sin wt.; or reversed:

   (a) 100 hz. : less than ± 100 mv. (± 0.10% FS)

   (b) 400 hz. : less than ± 300 mv. (± 0.30% FS)

   (c) 1 Khz. : less than ± 1.0 v. (± 1.0% FS)

   (d) 10 Khz. : less than ± 15 v. (± 15% FS)

10. Multiplier square-wave response (transient response):

   (a) 20 v. p-p. time delay: to 0.02% FS, less than 60 microseconds
   to 0.005% FS, less than 300 microseconds

   (b) 200 v. p-p. time delay: to 0.02% FS, less than 500 microseconds
   to 0.005% FS, less than 800 microseconds

   (c) Overshoot, any step: less than 0.02% FS.

11. Multiplier recovery from 10,000% overload (0-100 v. on X, Y, with 1 Kilohm input Rs)

   (a) to linear range: less than 5 milliseconds

   (b) to within 20 mv. (0.02%) of final value: less than 50 milliseconds

12. Multiplier worst-case crosstalk: Adjacent channels, one at 200 v. p-p., 1 Khz.: 80 db.
   (20 mv. p-p. on channel with grounded inputs)

13. Multiplier/Inverter equivalent output series inductance: less than 100 microhenries.

14. Multiplier/Inverter equivalent output shunt capacitance: more than one nanofarad.